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# Perspectives on the Top 50 Production Volume Chemicals

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Jul 80

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Part I examines the Top 50 in light of the Federal regulatory and other 'lists' containing them, with specific emphasis on the TSCA Inventory of Chemicals in Commerce. A comparison of this data base and two others is then made with regard to production volume. Part II contains a general discussion of the chemical 'trees' in which these chemicals are found and the implications of higher energy prices on their manufacture. Part III illustrates the use of the specific regulatory status and other lists summarized in Part I (as well as generally available production and use information) to characterize four members of the Top 50 list.
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July 1980

# PERSPECTIVES ON THE TOP 50 PRODUCTION VOLUME CHEMICALS

Prepared by

Program Integration Division

(J. Fitzgerald, D. Viviani, C. Berlin, D. Sterling)

With the Support of

Chemical Information Division

Office of Program Integration and Information

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## FOREWORD

In spring, 1980 the Program Integration Division created the Chemical Information and Analysis Project. By combining a knowledge of chemistry and chemical manufacturing processes with regulatory analysis and chemical marketing information, the Project is intended to review topical issues related to chemicals and identify trends and subject areas of interest to managers of chemical regulatory processes.

As an initial effort, a well-known list of chemicals (Chemical and Engineering News Top 50) was chosen to help illustrate the kinds of information that could be utilized and analyzed for the benefit of the policymaker. This brief report has four sections -- each illustrative of the use of data bases to analyze selected chemicals.

Part I examines the Top 50 in light of the Federal regulatory and other "lists" containing them, with specific emphasis on the TSCA Inventory of Chemicals in Commerce. A comparison of this data base and two others is then made with regard to production volume.

Part II contains a general discussion of the chemical "trees" in which these chemicals are found and the implications of higher energy prices on their manufacture.

Part III illustrates the use of the specific regulatory status and other lists summarized in Part I (as well as generally available production and use information) to characterize four members of the Top 50 list.

Part IV briefly examines the applicability of certain physical/chemical properties as indicators of exposure. The extent to which regulatory and other listings reflect these exposure indications is then discussed. Again, four Top 50 chemicals were selected for illustrative purposes.

In sum, this document is a collection of four papers designed to illustrate the kinds of readily available data and analysis that can be employed to provide insights (chemical process, marketing, and regulatory) into chemicals of interest to decisionmakers. We trust that an awareness of these insights, though incomplete, will be of interest to others as well.

Walter W. Kovalick, Jr.
Director
Program Integration Division

# PART I

## A. INTRODUCTION

Each year the Chemical and Engineering News (C&EN) publishes a report entitled "Facts and Figures for the U.S. Chemical Industry". Included in this report is a listing of the fifty largest volume production chemicals in the U.S. for the preceding year. This paper presents information profiles of these "Top 50"* chemicals using easily accessible (primarily ADP) information, and presents profile analyses for a subgroup of the top fifty. This paper will illustrate the types of information available to the Agency that can provide a gestalt of where a chemical(s) fits into the federal and industrial "hierarchy of concern," and demonstrates some of the different ways in which these general kinds of profiles can be viewed to yield more specific insights.

To accomplish the first objective, the Top 50 chemicals were: (a) individually screened** to determine their membership on various regulatory/chemical priority lists, and (b) examined in terms of their production volume distribution by means of the TSCA [Sec. 8(b)] Inventory.

* Chemical and Engineering News, May 5, 1980.
** Using CHEMTRAX which is an on-line data base and software system designed to help track Federal government decisions and actions on chemical substances. CHEMTRAX uses data from a variety of sources, including assessment reports, test results, criteria documents, and rules promulgated.

Both kinds of information are necessary to accomplish the second objective, namely, drawing insights or recognizing trends from those readily accessible information sources.

The resulting information profiles are, the "Federal Pedigree" of each of the chemicals (along with its geographic/volume distribution). This Federal Pedigree indicates which regulatory agency and/or professional or international group has investigated the chemical, and whether conclusions were reached or actions taken. This, along with production/site information provides a "picture" of how the federal complex views the chemical. In actuality, these profiles must be used with caution because of the limitations and biases inherent in the various data sources. For instance, membership of a chemical on a list indicates only that the chemical meets the listing criteria, not that it is necessarily a hazard. Absence of a chemical from a list provides no information, without first considering the candidate pool from which the list was drawn. Additionally, the production/volume information from the TSCA Section 8b Inventory, is incomplete due to claims of confidentiality.

In order to best utilize these profiles, it is first necessary to examine the limitations and biases in the data bases.

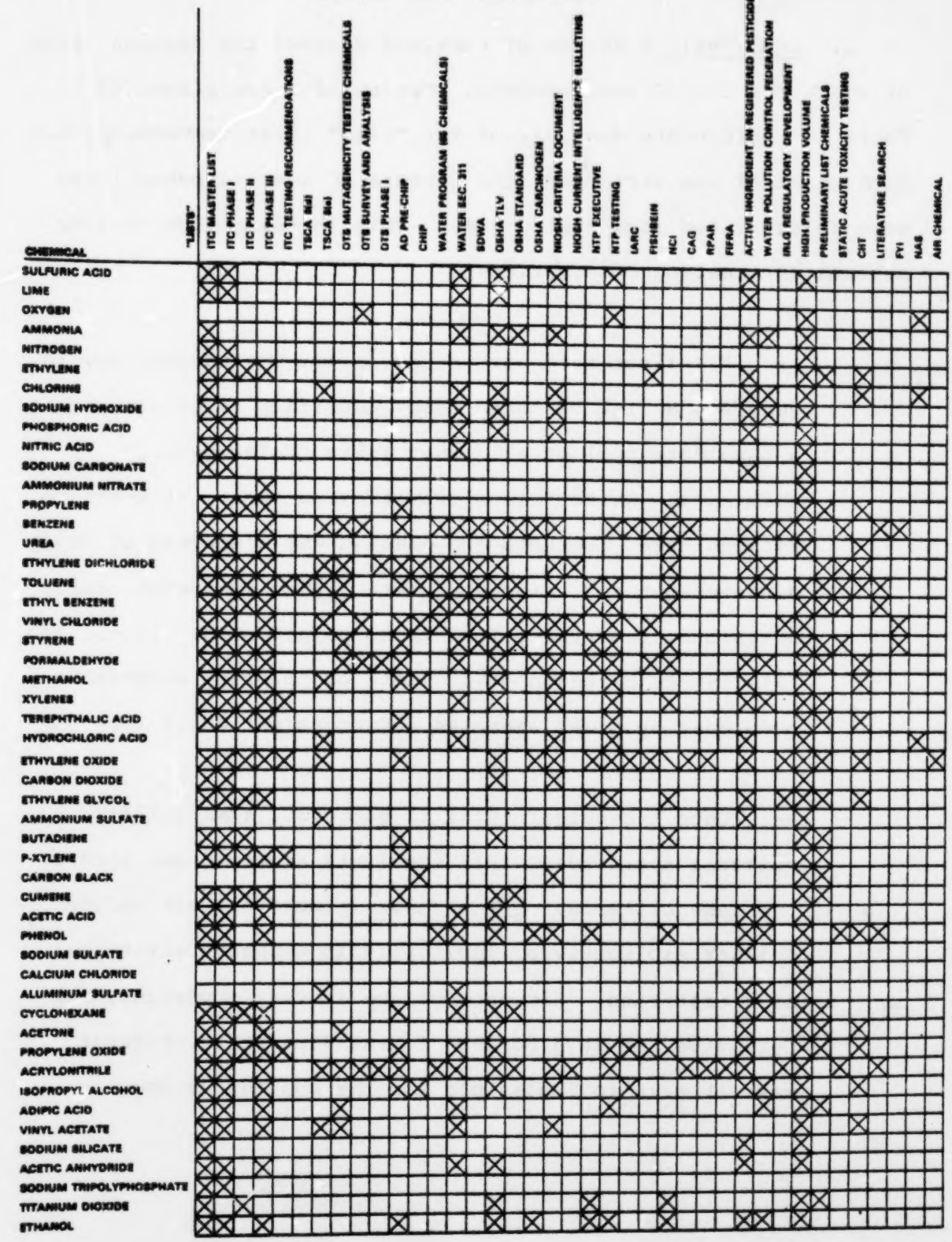
B. DISCUSSION OF INFORMATION SOURCES

1. CHEMTRAX: A search of CHEMTRAX yielded the various lists of which the Top 50 were members. The results are presented in Table 1. Before any analysis of the "hits" (list membership) for each chemical was performed, the genesis of some selected lists were investigated (see Appendix A). This investigation yielded several interesting observations:

-- All lists must have a beginning; the easiest way to generate a list of "dangerous" chemicals is to start from a candidate pool of all other lists of "dangerous" chemicals. While this approach makes sense, it tends to exclude newer products and inhibit the discovery of newly discovered toxic effects of established products. Early omissions, therefore, tend to be perpetuated. (e.g., the ITC list is based on other lists of priority substances developed by other agencies and organizations.)

-- Once a candidate pool is gathered, some culling criteria are needed. All the lists examined use some of the same criteria. For example, almost all use volume (either explicitly or implicitly in exposure estimates) as a criterion. Although volume is very important, its pervasive use in a Boolean format with other criteria make it next to impossible for the smaller volume

# TABLE I
## TOP 50 "LIST" MEMBERSHIP



chemical (or the chemical contaminant by-product) to gain admission to most regulatory or prioritization lists.

-- Most lists rely on the open literature for toxicity information; few listing entities conduct independent experimentation on considered chemicals. If there are no toxicity data in the open literature, the substance is often treated as if it is not toxic. It is therefore a serious misinterpretation for the layman to conclude that the absence of a substance on a list indicates it is not a hazard, since in this case toxic or potentially toxic chemicals are selected "out" because they do not meet the listing criteria, i.e. "toxicity information in the open literature" (e.g., IARC and CAG only prepare reports on substances for which there is adequate toxicity information available in the open literature.)

-- Conversely, many lists will exclude a chemical if the hazard presented by the chemical is well established. Since the presence of a chemical on a list is often used as an index of the hazard of the chemical, this selecting out of well-characterized substances might result in the erroneous conclusion that the chemical is not a hazard. The ITC selection process, for example, takes this into account, and does not recommend for testing chemicals for which the hazards are well established.

The situation then, as to the meaning of list membership can be summed up as "them that has, gets - sometimes!" The extent of inbreeding and reinforcing duplication is clearly illustrated in Figure 1. As is apparent from this diagram, all but 2 (IARC and Sec. 311) of the 10 listing entities investigated use volume as a criterion (explicitly or implicitly)* and only one, NIOSH, draws its candidate pool from a broad base. Any analysis of a chemical that uses "list membership" as a factor must take into account this inbreeding and duplication with the resultant distortion and bias inherent in these listings.

2. TSCA Inventory: This section reviews the uses and limitations of the TSCA Inventory, as discussed in other reports**, within the context of applying Inventory data to the Top 50 analysis.

Under the authority of TSCA, manufacturers processors and importers of chemical substances are required to: (1) report the identity of each chemical substance manufactured or imported at each site for a commercial purpose, (2) estimate the amount

*Although OSHA TLV (pre-1972) and CAG do not use volume explicitly as a criterion, it is used implicitly by the manner in which they draw their candidate pools.

**See especially "Illustrative Uses of the TSCA Inventory", Bob Janney and Ed Brooks, Unpublished Paper, Dec., 1979.

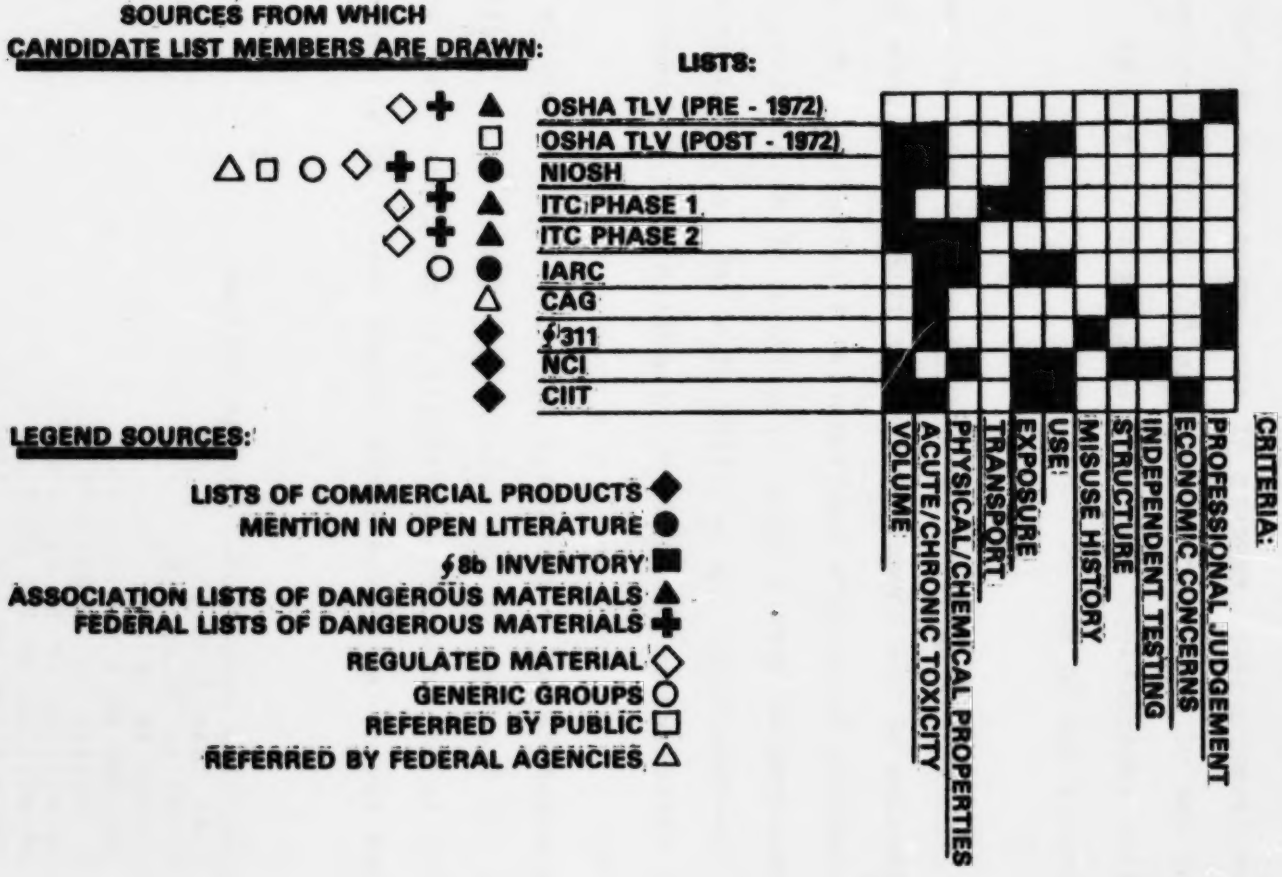



**FIGURE 1: LIST DERIVATION STRUCTURAL ELEMENTS**

imported or manufactured during calendar year 1977*, and (3) to indicate whether the substance is used only within one site. There are idiosyncratic aspects of the inventory which inhibit efficient use of the information: The confidential business information restrictions and the use of reporting ranges (particularly the Po and Pn ranges.)

a) Confidential Business Information: The most serious limitation of the Inventory in this type of analysis is the requirement to exclude confidential information. The problem is exacerbated when a large proportion of manufacturing sites are non-reporting, the severity of which is dependent on the site distribution for both the reporting and non-reporting sites.

Manufacturers may claim their production volume and/or their name and location confidential. The former claim would result in an inaccurate portrayal of the "size", ie. volume, of the sites, while the latter would result in an incomplete

*The reporting ranges used are as follows:
PO - less than 1000 lb.
P1 - 1,000 to 10,000 lb.
P2 - 10,000 to 100,000 lb.
P3 - 100,000 to 1 million lb.
P4 - 1 million to 10 million lb.
P5 - 10 million to 50 million lb.
P6 - 50 million to 100 million lb.
P7 - 100 million to 500 million lb.
P8 - 500 million to 1 billion lb.
P9 - over 1 billion lb.
PN - No 1977 production
PBlank - confidential

picture of the geographic distribution of the sites. (TSCA confidential inventory figures represented significant amounts of the total volume in 19 of the top 50 chemicals.) For example, a comparison of the number of reporting sites producing acrylonitrile by location gave the following information:

(1) it was producted at 9 (reporting) sites within 4 regions (Regions: 2 4, 5, and 6).

(2) it was produced within six states (Georgia (1), Louisiana (1), New York (2), Ohio (1), Tennessee (1), and Texas (3)).

A comparison of reporting sites by production range gave the following results: 2 (reporting) sites reported in the Pn range, 1 site in Po, 1 site in P4, 3 (reporting) sites in P7 and 3 in P blank, for a total of ten sites.

Clearly, one site reported its production volume (P4), but withheld information on its name and whereabouts -- More disconcerting is that, in some cases, no information on a site is available through the public inventory. In general, sorts of this type become futile although a few trends do emerge. (See Section D)

b) Reporting Range: A second limitation is the use of the Pn, Po and Pblank ranges in reporting. The Pn entry is used when a substance was not manufactured or imported during calendar year 1977. Because the Inventory is static (only for 1977) and because it is not unusual for a company to manufacture large amounts of a chemical one year and none the next (depending on marketing factors, s.a. stockpiles, demand, etc.), it may be misleading to use the Inventory to establish a profile of the chemical industry.

The Po entry is used when a company has manufactured or imported less than 1000 pounds in 1977. It seems uneconomical for a company to manufacture or import a high volume chemical, s.a. a Top 50, in less than thousand pound quantities, yet such a range was reported for about 80% of the Top 50. This might indicate that the substance in question is part of a mixture, or that the respondent did not understand the reporting requirements.

The Pblank entry is used when a company does not wish to disclose volume information. Analysis of volume figures can indicate certain characteristics of the producing industry. Some of this information would be helpful for regulatory strategy. The Pblank range inhibits these uses.

c) TSCA Inventory versus Other Estimates: The Agency has several sources available for estimating production volume. These include: the TSCA inventory, The International Trade Commission, C&EN, the Stanford Research Institutes Chemical Economics Handbook, and information contained in the responses to Sec. 308 letters under the Clean Water Act. Table 2 displays the production volume figures from several of these sources. Volume figures for C&EN were compared to the Public and non-Public Inventory. In 48% of the cases, the C&EN figure fell within the Inventory 98% confidence interval. In 42% of the cases, the C&EN figures were higher than the upper limit on the confidence interval of the TSCA Public Inventory. In 10% of the cases, the C&EN was lower than the lower limit of the confidence interval on the TSCA Public Inventory. For the Top 50 it appears that the Inventory tends to report lower volumes than C&EN. The C&EN figures are derived from other government and industry sources. Explanation of the production volume discrepancies may be due to idiosyncracies in the reporting requirements mandated under different statutes (i.e., International Trade Commission).

The TSCA Public Inventory does not contain complete information on many chemicals. Some information is classified confidential. The International Trade Commission and Sec. 308 letters are future sources of production volume

TABLE 2

ANALYSIS OF PRODUCTION VOLUME STATISTICS

| CAS# | NAME | (A) | (B) | (C) | (D) |
|---|---|---|---|---|---|
| 7644939 | SULFURIC ACID | 83.98 | 50 (38-70) | $44 \times 10^9$ | 17.7% |
| 1305788 | LIME | 38.78 | 6 | | 8.7% |
| 7664417 | AMMONIA | 36.24 | 6 (2-6) | | 11.1% |
| 7782447 | OXYGEN | 35.35 | 0.7 (0.3-0.9) | | 65.0% |
| 7727379 | NITROGEN | 29.92 | 4 (2-7) | | 30.0% |
| 74851 | ETHYLENE | 29.19 | 20 (15-30) | $7.45 \times 10^9$ | 12.9% |
| 1310732 | SODIUM HYDROXIDE | 24.78 | 30 (20-30) | | 8.4% |
| 7782505 | CHLORINE | 24.22 | 10 (10-20) | | 7.0% |
| 7644382 | PHOSPHORIC ACID | 20.27 | 10 (10-20) | | 6.5% |
| 7697372 | NITRIC ACID | 17.13 | 10 (10-20) | | 17.8% |
| 497198 | SODIUM CARBONATE | 16.51 | 20 (20-30) | | 11.1% |
| 6484522 | AMMONIUM NITRATE | 15.60 | 10 | | 20.0% |
| 115071 | PROPYLENE | 14.30 | 20 (13-30) | | 9.7% |

Col A - Production volume, Chemical Engineering News Information in C & EN is derived from the International Trade Commission, Bureau of Mines, Census Bureau & Industry Reports (billions of lbs.)

Col B - Production Volume, TSCA public inventory. First figure represents the mean aggregate volume. 95% Confidence Interval is within parentheses (billions of lbs.)

Col C - Production Volume, Stanford Chemical Economics Handbook (1976) (billions of lbs.)

Col D - The % of reporting sites reporting in the P-blank category. Company reports production but does not disclose production volume.

| CAS # | NAME | (A) | (B) | (C) | (D) |
|---|---|---|---|---|---|
| 57136 | UREA | 13.53 | 10 (8-10) | | 14.0% |
| 71432 | BENZENE | 12.72 | 10 (10-20) | $1.44 \times 10^9$ gal $10.66 \times 10^9$ lbs. | 7.1% |
| 108883 | TOLUENE | 11.86 | 10 (10-20) | $1.14 \times 10^9$ | 18.7% |
| 107062 | ETHYLENE DICHLORIDE | 11.82 | 10 (9-20) | | 21.4% |
| 100414 | ETHYLBENZENE | 8.53 | 7 (5.3-15) | $0.143 \times 10^9$ | 17.2% |
| 75014 | VINYL CHLORIDE | 7.54 | 6 (5-7) | $8.04 \times 10^9$ | 12.5% |
| 100425 | STYRENE | 7.48 | 5 (3.7-11) | $6.11 \times 10^9$ | 21.9% |
| 067561 | METHANOL | 7.41 | 6 (4.2-10) | $6.24 \times 10^9$ | 30.3% |
| 100210 | TEREPHTHALIC ACID | 7.26 | 0.500 (0.201-0.800) | $1.53 \times 10^9$ | 62.5% |
| 124389 | CARBON DIOXIDE | 7.07 | 4 (3-4) | | 24.5% |
| 1330207 | XYLENE | 6.89 | 10 (8.4-20) | $1 \times 10^9$ | 11.7% |
| 50000 | FORMALDEHYDE | 6.45 | 3 (2-7) | $5.62 \times 10^9$ | 18.0% |

Col A - Production volume, Chemical Engineering News Information in C & EN is derived from the International Trade Commission, Bureau of Mines, Census Bureau & Industry Reports (billions of lbs.)

Col B - Production Volume, TSCA public inventory. First figure represents the mean aggregate volume. 95% Confidence Interval is within parentheses (billions of lbs.)

Col C - Production Volume, Stanford Chemical Economics Handbook (1976) (billions of lbs.)

Col D - The % of reporting sites reporting in the P-blank category. Company reports production but does not disclose production volume.

| CAS # | NAME | (A) | (B) | (C) | (D) |
|---|---|---|---|---|---|
| 764010 | HYDROCHLORIC ACID | 5.95 | 7 (4-10) | | 24.0% |
| 75218 | ETHYLENE OXIDE | 5.28 | 3 (2-4) | | 17.6% |
| 107211 | ETHYLENE GLYCOL | 4.60 | 4 (2-4) | $3.4 \times 10^9$ | 24.5% |
| 106423 | P-XYLENE | 4.18 | 5 (3.7-11) | $3.2 \times 10^9$ | 16.0% |
| 98828 | CUMENE | 4.00 | 4 (2-7) | | 18.0% |
| 7783202 | AMMONIUM SULFATE | 3.94 | 5 (4-5) | | 22.7% |
| 106990 | BUTADIENE,(1,3-) | 3.55 | 4 (3-5) | $3.2 \times 10^9$ | 24.6% |
| 64197 | ACETIC ACID | 3.33 | 4 (3-4) | $0.538 \times 10^9$ | 32.5% |
| 7740448 | CARBON BLACK | 3.33 | 0.7 (0.3-0.8) | | 26.5% |
| 108952 | PHENOL | 2.95 | 2 (2-3) | $3.13 \times 10^9$ | 26.7% |
| 67461 | ACETONE | 2.50 | 1 (1-2) | $2.1 \times 10^9$ | 38.2% |
| 10043013 | ALUMINUM SULFATE | 2.46 | 2 (1-2) | | 30.5% |
| 110827 | CYCLOHEXANE | 2.41 | 2 (2-3) | | 9.5% |

Col A - Production volume, Chemical Engineering News Information in C & EN is derived from the International Trade Commission, Bureau of Mines, Census Bureau & Industry Reports (billions of lbs.)

Col B - Production Volume, TSCA public inventory. First figure represents the mean aggregate volume. 95% Confidence Interval is within parentheses (billions of lbs.)

Col C - Production Volume, Stanford Chemical Economics Handbook (1976) (billions of lbs.)

Col D - The % of reporting sites reporting in the P-blank category. Company reports production but does not disclose production volume.

| CAS # | NAME | (A) | (B) | (C) | (D) |
|---|---|---|---|---|---|
| 7757826 | SODIUM SULFATE | 2.34 | 4 (3-4) | | 16.3% |
| 75569 | PROPYLENE OXIDE | 2.25 | 1 | $1.87 \times 10^9$ | 37.5% |
| 10043524 | CALCIUM CHLORIDE | 2.03 | 1 (0-6-1) | | 34.0% |
| 107131 | ACRYLONITRILE | 2.02 | 0.7 (0.4-1.1) | $1.64 \times 10^9$ | 37.0% |
| 108054 | VINYL ACETATE | 1.98 | 1 (.7-1) | | 20.0% |
| 67630 | ISOPROPYL ALCOHOL | 1.97 | 0.7 (0.511-1) | $1.72 \times 10^9$ | 46.4% |
| 124049 | ADIPIC ACID | 1.80 | (1-2) | $1.5 \times 10^9$ | 12.5% |
| 6834920 | SODIUM SILICATE | 1.55 | .1 (0.1-0.2) | | 13.0% |
| 7758294 | SODIUM TRI-POLYPHOSPHATE | 1.51 | 2 (1-2) | | 0% |
| 108247 | ACETIC ANHYDRIDE | 1.51 | 1 (1-2) | | 33.3% |
| 13463677 | TITANIUM DIOXIDE | 1.48 | .8 (0.5-1) | | 23.4% |
| 64175 | ETHANOL | 1.31 | 1 (1-2) | $0.508 \times 10^9$ | 27.5% |

Col A - Production volume, Chemical Engineering News Information in C & EN is derived from the International Trade Commission, Bureau of Mines, Census Bureau & Industry Reports (billions of lbs.)

Col B - Production Volume, TSCA public inventory. First figure represents the mean aggregate volume. 95% Confidence Interval is within parentheses (billions of lbs.)

Col C - Production Volume, Stanford Chemical Economics Handbook (1976) (billions of lbs.)

Col D - The % of reporting sites reporting in the P-blank category. Company reports production but does not disclose production volume.

information although certain (confidentiality) constraints exist. This matter needs further exploration.

The TSCA Inventory production figures were compared to production figures from the Stanford Research Institutes (S.R.I.) Chemical Economics Handbook. 62% of the Stanford figures fell within the 95% confidence interval on the TSCA inventory. (5% were higher, and 28.5% were lower.) SRI's figures represent 1976 production. TSCA Inventory represents 1977 production figures.

PART II

## C. DISCUSSION OF THE TOP 50

Table 2 lists the C&EN Top 50 chemicals along with their production volume*. The C&EN's definition of a "chemical" is not congruent with TSCA's definition. This becomes apparent when the Section 8(b) Inventory's 50 highest volume products are matched with the C&EN's list. There is a 50% overlap of the two lists (i.e., 25 Top 50 chemicals are found in the TSCA inventory's 50 highest volume products). Certain classes of substances are not considered for purposes of the C&EN listing. Those classes of substances excluded are: fuels (s.a., hydrogen, methane, and propane), minerals (e.g., copper, sulfur, and sodium chloride), and polymers (e.g., stryene-butadiene). To complicate matters further, the list does include oxygen, nitrogen, ethylene, calcium chloride, and carbon dioxide (but not carbon monoxide).

The C&EN Top 50 is composed of twenty inorganic and thirty organic chemicals. The organic chemicals are mostly monomers of plastics, rubbers or fibers and, to a lesser extent, solvents, fertilizers, and antifreeze (almost all are intermediates of some kind). The inorganics run the spectrum of elements, acids, bases, and salts, both used directly or used as intermediates. Many of the organics are of recent origin and not naturally found in the environment (e.g. vinyl chloride, acrylonitrile). This is not true of the C&EN Top 50 inorganics which are all found in

* C&EN lists their sources as: Bureau of the Census, Bureau of Mines, International Trade Commission, and C&EN's own estimates.

nature in much greater than trace amounts (with the exception of sodium tripolyphosphate).

A voluminous amount of information is available on the Top 50 chemicals owing to the quantities in which they are produced. As mentioned in a previous section, one major criterion for inclusion of a chemical for investigation (by a government agency or private association) is its potential for exposure (i.e., volume). The Top 50 chemicals are, therefore, well studied.

Because of the large quantities of easily accessed information on the Top 50, it provides an excellent opportunity to gain a better perspective on the TSCA inventory figures. That these chemicals are well studied also makes them useful candidates for profile analysis, since their profiles are replete with information. On the debit side, it must be acknowledged that large volume chemicals are not representative of the many families of chemicals that TSCA is likely to deal with as a general rule, since they are mostly synthetic intermediates. Chemicals with other uses* (i.e., plasticizers, insulators, etc.) will be profiled in the future in order to "fine tune" the profile and analysis procedure on other chemicals typical of OPTS concern.

* And therefore other physical-chemical properties, and by extension risks.

## D. GENERAL ANALYSIS

Since all of the organics in the Top 50 have oil/gas feedstocks, the largest factor which will affect the future of the organic chemical industry will be increased oil/gas prices and the loss of the competitive advantage the industry has enjoyed because of artificially low U.S. petroleum prices. Eventual deregulation will hit the organic chemical industry harder than most. Not only is energy needed for normal production, maintenance, etc, but the feedstocks for most products are directly derived from, and in many cases, directly usable as fuel. [Figure 2 illustrates the dependence of the industry on oil and gas for feedstock.] This state of affairs from an economical and engineering viewpoint provides the Agency with another method of prioritizing chemicals for future analyses. The expected rise in the cost of oil and gas should overwhelm most other economic factors. Based on this, it is expected that chemicals meeting the following specifications will undergo either shifts in market-share or be subject to process change:

1) Chemicals for which alternative feedstocks are available. All organics in the Top 50 presently are dependent upon petroleum or natural gas for feedstocks. Presently natural gas is both cheaper and more abundant. Its market condition is also more stable since most of its supply is domestic. Consequently, natural gas liquids have been substituted as much as possible for oil-based naphtha as feedstock. In addition, this shift is also

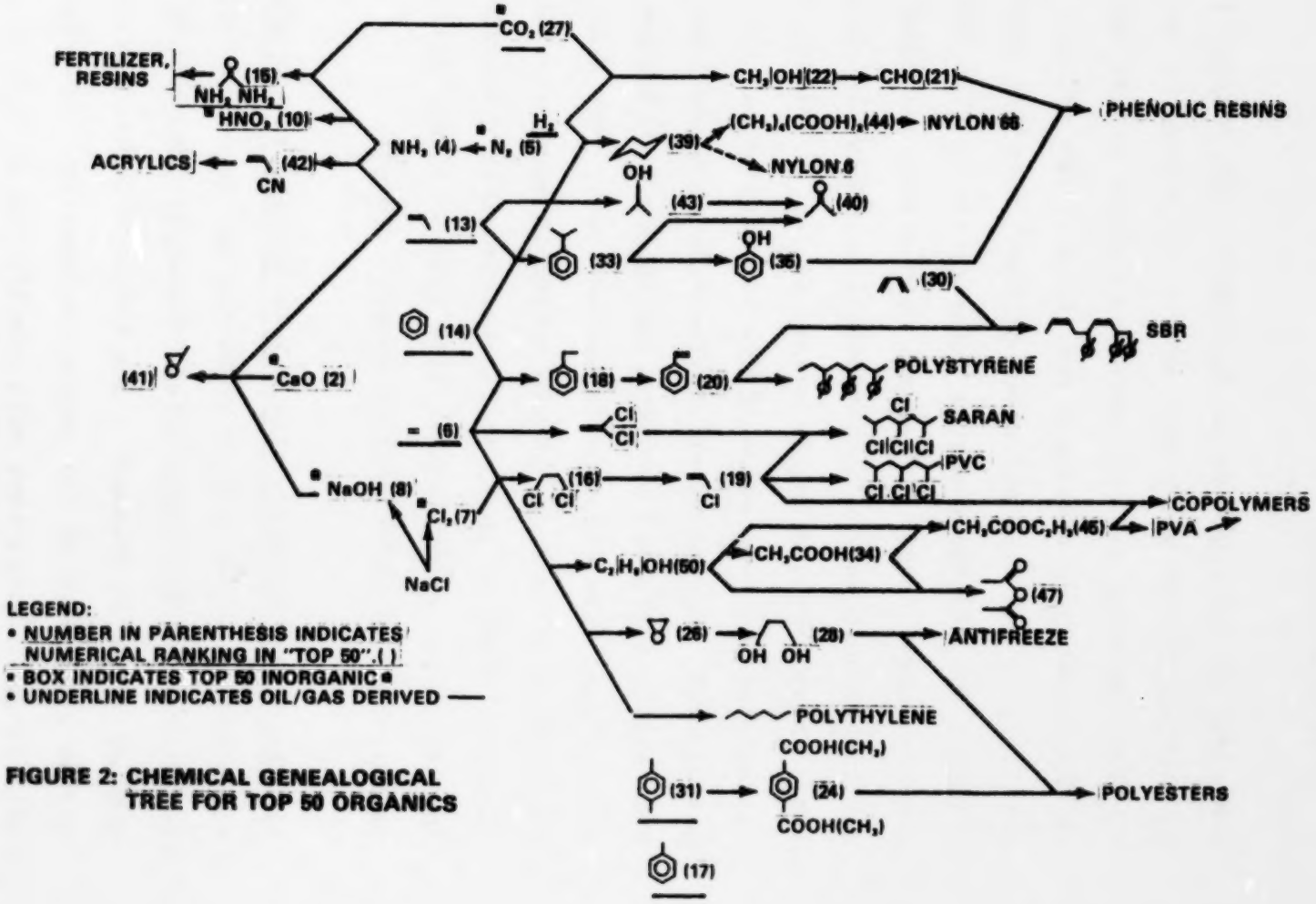



**FIGURE 2: CHEMICAL GENEALOGICAL TREE FOR TOP 50 ORGANICS**

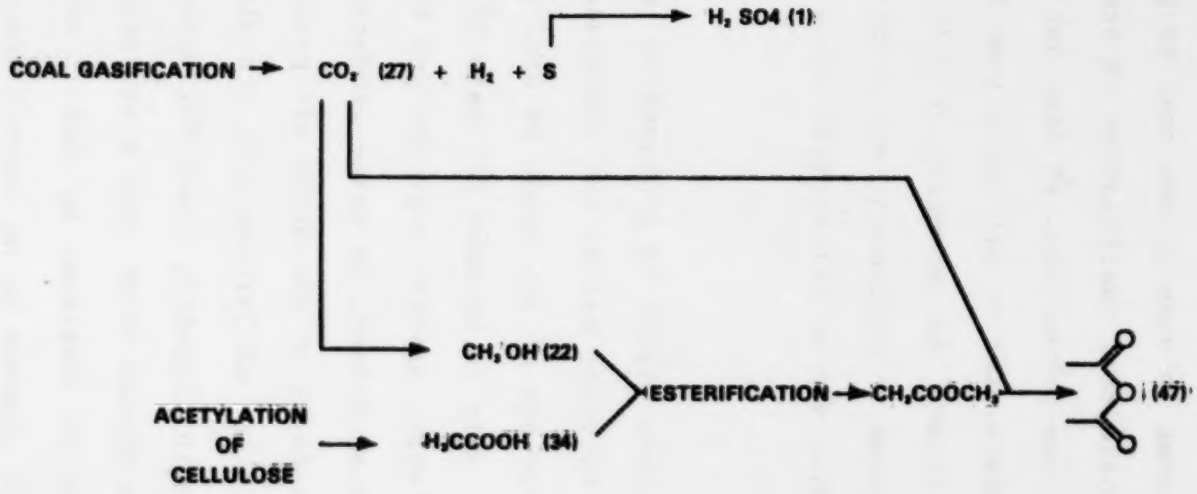
occurring for natural gas-based organics (e.g., a shift from ethylene to methanol as a feedstock for acetic acid).

Figure 3 illustrates how Kodak intends to use coal to produce three Top 50 organics*. While coal gasification is presently more expensive than oil or gas production, it does not present the same availability problems, and as oil/gas prices increase, it will become more competitive. An extension of this point is the use of alternate processes to circumvent the problem of feedstock availability. This can be illustrated using ethylene glycol.

Presently, almost all ethylene glycol is produced by the oxidation of ethylene (to ethylene oxide) and subsequent hydration to the diol. Only 60% of the oxide is used for the production of the glycol. This is because the sale of nonglycol derivatives is more profitable, meaning that the key factor in glycol production, other than demand, is oxide production, not glycol capacity. The dependence on the oxide was predicted to change with the recent addition of Oxirane into the glycol market. A new 800 million lb. capacity plant for Oxirane Chemicals recently came on-stream which uses a new process (liquid-phase acetoxylation of ethylene) to convert ethylene directly to ethylene glycol without going through the ethylene oxide intermediate. This plant was supposed to slow down the demand for ethylene oxide, but it has recently shut down due to

* C & E News, January 14, 1980

**FIGURE 3: ALTERNATIVE FEEDSTOCK PRODUCTION FOR SOME TOP 50 CHEMICALS**




**LEGEND:**

(1) SULFURIC ACID
(22) METHANOL
(27) CARBON MONOXIDE
(34) ACETIC ACID
(47) ACETIC ANHYDRIDE

ALL ORGANICS IN THE TOP 50 ARE AT PRESENT DEPENDENT UPON OIL/GAS FEEDSTOCKS (FIGURE 2). ABOVE IS AN EXAMPLE OF HOW KODAK INTENDS TO USE COAL TO PRODUCE THREE TOP 50 ORGANICS (AND ONE TOP 50 INORGANIC).

corrosion problems. Other manufacturers are currently pushed to capacity in order to meet strong demand and the loss of the Oxirane plant has increased the problem.

2) Chemicals for which more than one type of petroleum feedstock is needed. These will be proportionately affected and more susceptible to feedstock availability fluctuations. An example of this is styrene-butadiene rubber (SBR, Figure 2), which is made from benzene, ethylene, and butadiene: feedstocks derived from different energy sources. Ethylene is primarily produced from the cracking of natural gas, while benzene and butadiene primarily from petroleum fractions (benzene from the BTX reformate and butadiene from cracking).

3) Chemicals which do not have petroleum/natural gas feedstocks or which use a petroleum product not directly usable as fuel. Furfural (an intermediate in the production of furan and tetrahydrofuran compounds) made from agricultural residues s.a. corncobs and cornstalks is an example of the former, formaldehyde and its subsequents is an example of the latter (Figure 2). Formaldehyde and urea are manufactured mainly from carbon dioxide which is petroleum-derived but carbon dioxide is a non-fuel byproduct, i.e. it does not compete as a fuel.
This point can be extended to chemicals that are made from petroleum feedstocks not in heavy demand (e.g. petroleum residuals versus distillates).

Two final observations can be made. The energy crisis is causing chemical companies to integrate backwards, i.e. towards feedstocks rather than toward retailing. This is done to ensure adequate supplies. This may have the effect of forcing out the smaller manufacturer (except those producing speciality chemicals) and favor processes which show greater economies of scale.

Lastly, all the synthetics produced from organic monomers in the Top 50 replace natural products; these natural products may become more competitive as the cost of synthetics rise. Also, many plastics compete with each other while others, because of unique properties, have no other synthetic competitors (e.g. styrene-butadiene rubber*). The latter may have a less elastic demand and will therefore retain its place in the market.

Several other general observations on the top 50 are manifest from manipulation of Inventory data (see Appendix B for illustrative histograms):

The inorganic chemicals in the Top 50 are manufactured throughout the ten regions. Sulfuric acid is produced in 42 states. This is not the case for the production of the organic chemicals in the Top 50. Some, like formaldehyde and urea, are manufactured throughout the country, while others such as vinyl chloride

*As claimed by the manufacturer.

(region 6) and terephathalic acid (region 4) are produced almost entirely in one region. Benzene and ethylene, though produced throughout the U.S. (except region one for ethylene), are mainly concentrated in region six and to a lesser extent region two. Sulfuric acid is produced in the most states (42); propylene oxide is produced in the least number of states (4).

# PART III

## E. SAMPLE PROFILE ANALYSIS

This section will attempt to demonstrate ways in which the available data/information can be analyzed for decision-making purposes.

### 1. Cumene Profile

a) Commercial Use: Cumene is a high volume chemical, ranked thirtieth (4.00 billion lb.) according to C&EN's Top 50 list. It is produced at 22 manufacturing sites* with 32% of the sites and 52% of the total production volume reporting in the one hundred million to five hundred million (P7)** range. There are 9 cumene producing sites in Texas, 3 producing sites in Illinois, Pennsylvania, and New York. Cumene is produced in only 10 of the 50 states, but in 6 of the 10 Federal regions.

It is commercially produced from the reaction of benzene and propene over an appropriate catalyst. It is used primarily for the production of phenol and acetone by hydroperoxidation. It is a component in aviation fuels and a catalyst for acrylic and polyester-type resins.

* Only includes sites reporting non-confidential figures for 1977.

** 8(b) Inventory.

b) Federal Profile and Analysis: Cumene has undergone ITC Phase I and Phase II evaluation. In addition, an OSHA TLV (threshold limit value) and standard exist. The data show that there is some evidence of teratogenicity (though not conclusive) and, possibly, carcinogenicity. Except for ITC analysis, cumene has essentially undergone no regulatory investigation for oncogenic activity, despite the structural similarity it shares with benzene, toluene, xylene, and ethylbenzene. The high production volume has led to investigation of the chemical by the EPA Office of Water Planning and Standards. Given the broad base of the spill regulation candidates (under Sec. 311 of the Clean Water Act) (see Figure 1) and the breadth of the investigation (by that office), it is surmised that cumene does not present an important aquatic risk* since it is not listed under either source.

* Cumene is a very high volume chemical, often transported. Its absence on the Sec. 311, CWA list means that there have been no serious accidents (s.a., fish kills) resulting from its transport. It apparently does not meet the Sec. 311 aquatic toxicity cut-off since it was surely in the initial toxicity 311 candidate pool. This suggests it is of low aquatic toxicity.

Table 3

CUMENE PROFILE

CAS#: 98-82-8

Inventory Volume: 4.0 billion lb

CHEMTRAX:

000711 - Cumene

ITC* Phase I: NO. Exposed: 000.016

ITC Phase I: Exposure Frequency: 000.049

ITC Phase I: Exposure Intensity: 000.016

ITC Phase I: Penetrability: 000.166

ITC Phase I: Quantity Released: 000.166

ITC Phase I: Persistence: 000.033

ITC Phase II: Carcinogenicity: -01.000

ITC Phase II: Mutagenicity: -01.000

ITC Phase II: Teratogenicity: 001.000

ITC Phase II: Acute Toxicity: 001.000

ITC Phase II: Other Toxic Effects: -00.930

ITC Phase II: Ecological Effects: 000.670

ITC Phase II: Bioaccumulation: -01.000

* Generally, for ITC Phase I and Phase II, the higher the score, the more pronounced the effect. For Phase II, the scores range from -3.0 to 3.0. Positive scores denote weak (low number) to strong (high number) evidence for the effect, while negative scores denote weak (low number) to strong (high number) suspicion of the effect (based on structure/activity, etc.) A zero score indicates negative results were found when tested.

OTS Mutagenicity Tested Chemicals: No

CAG Chemicals: No

IARC Monographs: No

NAS Report Availability: No

NTP Executive Summary: No

OSHA TLV: Yes

OSHA Standards: Yes

Water Pollution Control Federation: No

AD Pre-Chip: Source: Interagency Testing Committee Scores

AD Pre-Chip: Disposition:

TSCA Sec. 8e Actions: No

ITC Testing Recommendations: No

Data Sources:

ITC Master File

ITC Phase I Score File

ITC Phase II Score File

ITCPhase III Score File

OSHA TLV

OSHA Standards

A D Pre-CHIP Screenings

Preliminary List Chemicals

Highest Production Volume Chemicals

2. Acrylonitrile Profile

a. Commercial Use: Acrylonitrile is a high volume chemical, ranked forty-second (2.02 billion pounds) according to the C&EN survey. According to the Inventory, acrylonitrile was produced at 8 sites in 1977, with three of these sites claiming confidential volume figures. Two additional sites reported no 1977 production. Discrepancies became apparent when the number of sites per state/region were examined. There were nine sites (in total) within the ten regions and within the 50 states. This indicates that one manufacturer (or importer) claimed its name and location confidential, but not their production volume.

Acrylonitrile is a flammable liquid with a boiling point of 77°C (1 atmosphere) and a vapor pressure of 80 mm (20°C). It is commercially produced by the catalytic oxidation of propene and ammonia over a catalyst. It is used primarily in the production of acrylic and modacrylic fibers. It is also used in acrylonitrile-butadiene-styrene (ABS) and styrene-acrylonitrile resins (SAN).

b) Federal Profile and Analysis: Acrylonitrile has undergone ITC Phase I and Phase III evaluation. There are both Federal air (OSHA and EPA) and water (EPA) standards (Water Programs 65 Chemicals and Sec. 311) promulgated and being considered for its control, as well as product standards (CPSC). FDA has banned the use of acrylonitrile in plastic

beverage containers. From the physical/chemical properties, acrylonitrile would be expected to be found in both the hydrosphere and atmosphere and to transport easily into the air from water. (Acrylonitrile has a vapor pressure of 100 torr (20°C), diffuses through air quickly and is soluble to 7% in water at 20°C.) Given its high volume production, widespread use and widespread exposure (i.e. via entrained monomers) could be reasonably expected, barring easy decomposition. As to the sister element of exposure in the risk equation (i.e. effect), acrylonitrile is presently being investigated by Cancer Assessment Group, OPTS, and National Toxicological Program.

**PART IV**

F. Sample Analysis Using Physical/Chemical Properties of A Homologous Series (Benzene, Toluene, Ethylbenzene, and Cumene)

There are several ab initio methods to analyze or project potential environmental exposure of a chemical for which there is minimal or no empirical exposure information. Methods presently being employed include: (1) the structural analogue approach (chemicals with similar or identical structural elements may "behave" in a similar manner) and (2) ranking schemes in which known properties of the chemical are assigned weighted values and these values are applied to an algorithm, and the chemical ranked accordingly.

An alternative method of forecasting potential environmental exposure is by categorizing according to similarities over a wide range of physical/chemical (p/c) properties. (This differs from present methods which use p/c properties in weighted ranking schemes in that it categorizes chemicals into groups, rather than assigning values or prioritizing them.) Physical/chemical properties are quantitative measures of how chemicals behave under standardized conditions. These conditions are often analogous to environmental conditions. By searching available

data bases for chemicals with a "close fit", p/c property profile, to the compound of interest, a list of chemicals would emerge which:

a) Are likely to "behave" the same as the compound of interest relative to transport through the environment, lifetime, etc.

b) Are likely to have some of the same uses as the compound of interest (p/c properties often define potential uses).

The lists could then be scanned for chemicals with either high production volume, or widely dispersive* use. The presence (or absence) of these p/c "doppelganger" chemicals in the monitoring literature (or data bases, s.a., WATERDROP** and AIRDROP***) would be suggestive of the potential environmental dispersion of chemical of interest. In this way, potential exposure, could be estimated.

Obviously, this type of analysis is not entirely relevant to the Top 50, since the Top 50 chemicals have been well studied empirically. However, there is a series of analogs within the

*i.e., released to the environment as a function of use such as a detergent.

**Component of CIS. Distribution Registry of Organic Pollutants (in water).

***Distribution Registry of Organic Pollutants (in air). Not yet on-line (CIS).

Top Fifty which are illustrative of how this process works; Benzene, toluene, ethylbenzene and cumene are a homologous aromatic series, each differing by the addition of one alkyl carbon. Table 4 lists the p/c properties for this series. These properties highlight the following trends.

Given the same production and use circumstances* the following would be predicted:

Likelihood of air exposure from the series analogs decreases from benzene to cumene. (Vapor pressure decreases and molecular weight increases in this direction.)

Likelihood of water exposure from the series analogs decreases from benzene to cumene. (Water solubility** decreases even though dipole moment increases in this direction.)

These trends are further supported by the fact that the autoignition temperature decreases from benzene to cumene (which acts as a crude indicator of potential for decomposition). Also the vapor densities are well above unity, and in the same range,

* Production volumes are all similar as are types of uses (solvents or intermediates)

**Entropy effect from flickering water cluster overrides enthalpy effect from solvation.

TABLE 4

Physical Chemical Properties of a Homologous Series

| Physical Chemical Property | Benzene | Toluene | Ethylbenzene | Cumene |
|---|---|---|---|---|
| molecular weight | 78 | 92 | 106 | 120 |
| specific gravity (20°C) | 0.9 | 0.9 | 0.9 | 0.9 |
| flash point (°F) | 12 | 44 | 5.9 | 111 |
| vapor pressure, torr (20°C) | 76 | 22 | 7 | 3.2 |
| vapor density | 2.8 | 3.1 | 3.7 | 4.1 |
| autoignition temperature (°F) | 1044 | 997 | 810 | 795 |
| melting point (°C) | 5.5 | -95 | -95 | -96 |
| boiling point (°C) | 80 | 111 | 136 | 153 |
| thermal conductivity x $10^4$ (20°C) | 3.78(22°C) | 3.22 | 3.16 | 2.98 |
| saturated concentration in air, $g/m^3$ (20°C) | 319 | 110 | 40 | -- |
| dipole moment (gas phase), debye | 0 | 0.36 | 0.59 | -- |
| water solubility, mg/l (20°) | 1780 | 515 | 152 | 50 |
| heat capacity (Kcal/mole) | 32.4 | 37.5 | 44.5 | -- |

and the acute toxicities are similar so these two properties will exert no relative effect on the predicted trends.

If the information profile is analyzed in terms of these predictions, the following is manifest:

1) As a first estimate, it becomes apparent from the ranking of these Top 50 chemicals relative to list membership (benzene on 27 CHEMTRAX lists, toluene-26 lists, ethylbenzene-19 lists, cumene-8 lists), that the amount of "interest" elicited from regulatory and other groups parallels the projected exposure trends.

2) Benzene, toluene, and ethylbenzene are on the water programs list of 65 chemicals*, while cumene is not. Also, cumene is not included in Section 311, while the others are. This parallels the predicted sequence.

Again, it must be stressed that the above only illustrates how these p/c trends are harbingers of exposure. Typical future exercises would involve extensive searches for the p/c (and, if possible, use) doppelganger of the compound of interest and a search for empirical exposure data.

*List of 65/129 chemicals and chemical categories that the Office of Water Planning and Standards is required to address in the consent decree (NRDC v. Costle).

# APPENDIX A

## EVALUATION OF INFORMATION SOURCES

The purpose of this Appendix is to evaluate the various information sources mentioned in this report for the purpose of pinpointing the biases inherent in each source. The information sources are examined in terms of the procedures used for (1) targetting a chemical for consideration and (2) the criteria used for setting priorities.

ITC Phase I and Phase II Evaluation: The ITC initial list was derived from other lists of prioritized potentially hazardous substances developed by other agencies or organizations. Phase I evaluates a substance in terms of its potential for human exposure and environmental release cohite. Phase II examines its potential for adverse human and/or environmental effects.

Two points need to be made in connection with the interpretation of this information. First of all, chemicals that have not appeared on other lists, those not in commercial production or those covered by other regulations such as drugs, food additives, and pesticides will not have undergone Phase I evaluations. In addition, substances where use-information was unavailable will also not have undergone Phase I evaluation, though the committee will attempt to ascertain the missing details.

The second pitfall has to do with the elimination from consideration for Phase II evaluation of certain substances based on professional judgement. Substances that are (1) currently under regulation or considered for regulation, such as benzene and vinyl chloride, (2) reasonably well characterized hazards, such as mercury, (3) (essentially inert materials, such as polymers, and (4) natural products that would be difficult to characterize, such as wood or gasoline, would be dropped from Phase II evaluation.

In general, chemicals that have never been looked at will not have undergone Phase I evaluation while substances that are thought of as inert and those that are well-characterized will have undergone Phase I evaluation but not Phase II.

ITC Phase III, ITC Phase IV: These batteries of assigned tests are primarily updates of ITC Phase I and Phase II. First a Phase III exposure analysis is done and with the results the Phase IV biologic tests are performed. The chemicals studied come primarily from the ITC Master list. Chemicals are chosen for study by the ITC members. Members have the option to nominate new substances, not on the Master list, to receive Phase III and Phase IV testing.

Cancer Assessment Group Chemicals: The Cancer Assessment Group (CAG) assesses chemicals for the purpose of providing a judgement concerning the weight of evidence that an agent is a potential human carcinogen and if so, how great an impact is it likely to have on public health. Substances are recommended to CAG for assessment by the various program offices. Normally, the program offices use potential for exposure, i.e. volume, as the main criteria for recommendation. Once a recommendation is made, the chemical is assessed using information available in the open literature. Frequently, the IARC monographs serve as a guide into the literature on carcinogenicity. Available data are reviewed not only in terms of the actual results but also on the quality of the evidence.

Three types of evidence are used to identify substances that may pose a carcinogenic hazard. They are: (1) epidemiological evidence, (2) long-term bioassays on animals, and (3) suggestive evidence from structure-activity studies or from short-term or other tests known to correlate with carcinogenic activity. Normally, if a well designed epidemiology study shows a clear hazard, the substance is considered a CAG carcinogen. In the absence of epidemiological results, a substance may be classified as a potential human carcinogen on the basis of animal studies. A substance is classified as a suggestive carcinogen on the basis of structure or a positive Ames test when no other information is available.

OSHA TLV* and OSHA Standards: The Occupational Safety and Health Act of 1970 allowed OSHA to set standards by consensus for the first two years. This means a rulemaking process was not required to put any standard either public or private into law prior to 1972.

The OSHA TLVs, the recommended upper limit (ceiling) or time-weighed average concentration of a substance to which most workers can be exposed without adverse effect were adopted from the American Council of Government Industrial Hygenists (ACGIH). These TLVs were 1968 values. After 1972 a formal

* These were modified to mean permitted exposure limits as opposed to threshold level values.

rulemaking process was necessary for making changes or additions, i.e. setting standards.

A chemical becomes a candidate for consideration by one of three mechanisms: (1) results are recommendations from NIOSH (criteria document) (2) petition by an employer or representative of an employee, and (3) findings that the chemical in question is a carcinogen (by NIOSH, CAG, NCI, IARC, etc.)

This list is prioritized by evaluating the chemical in terms of toxicity, worker exposure, and the feasibility of implementing the regulation. (The OSHA carcinogen program has just undergone extensive changes.)

This list is biased towards chemicals that are highly toxic and/or carcinogenic and to which workers are exposed.

NIOSH Criteria Documents: NIOSH's initial list of substances is derived from: recommendations by government agencies and trade associations, the open literature, and the presence of a substance on a "list". The criteria used for prioritizing these substances are: worker exposure, volume, and toxicity. Criteria documents are written for the highest priority chemicals. The open literature is evaluated and from that a standard is recommended, though it is not binding. NIOSH's function is currently undergoing change.

Water Section 311 Chemicals: Section 311 of the Clean Water Act prohibits the discharge of hazardous chemicals into the navigable and coastal-shore waters of the U.S. The initial list contained all substances in commerce. A substance was eliminated from consideration if (1) there was no available date on its LC50 and (2) professional judgements indicated that the chemical was not of concern.

The remaining substances underwent a two phase selection process. The first phase consisted of evaluating substances in terms of their aquatic toxicity (96 hr. LC50 500 mg/l). Those substances meeting this criteria were deemed hazardous if it (1) had a spill history, (2) had a production volume of greater than one billion pounds and (3) was used primarily as a pesticide (even if it was produced in less than 1 billion lb. quantities). Substances produced in less than 1 billion lb. quantities for which the use was unknown or limited to research, medicinals, food additives, or analytical regents, were not considered. All other candidate substances not explicitly included in the Phase 2 criteria were judged in terms of their selling price. A candidate substance was eliminated from consideration if it had a high selling price. This was done to ensure that materials of relatively low market price and high toxicity (met toxicological selection criteria) were given priority (i.e., deemed hazardous).

Certain biases are apparent in this list. Chemicals not in commerical production and those without a 96 hr. LC50 in the open literature were eliminated from consideration along with those eliminated due to professional judgement. Those chemicals produced in less than one billion pound quantities for which no use was known were also systematically eliminated. Of greater concern was the use of market price as a criteria for judging chemicals produced in less than one billion pound quantities. Substances that met toxicological criteria were systematically eliminated if the selling price was high.

International Agency for Research on Cancer (IARC) Monographs: The IARC monographs provide critical reviews of data on carcinogenicity of groups of chemicals for which human exposure has been demonstrated. Besides evaluating the data in terms of human risk, areas in which additional research is needed are indicated.

Two main criteria are used in the selection of chemicals: (1) evidence of human exposure and (2) experimental evidence of carcinogenicity and/or evidence or suspicion of risk to humans. Inclusion in the monographs does not imply that a chemical is carcinogenic, only that it has been examined. On the other hand, absence does not indicate non-hazard.

NCI BioAssays: NCI uses as an initial data source (input) all substances in commerce. For the purpose of setting

priorities, all these substances are evaluated according to the following criteria: (1) production volume, (2) distribution and use, (3) structural relationship to other substances known to be toxic, (4) number and kinds of people exposed, (5) physiochemical properties, and (6) legislative history/status. Chemicals are picked for testing by a chemical selection workgroup using profession-judgement and federal agency recommendations. Certain substances are considered high priority for testing purposes due to their use and exposure such as: pharmaceuticals, food additives, pesticides, and household products. Due to the high cost and lengthy time span required for animal bioassays, only the highest priority chemicals can be tested.

Chemical Industry Institute of Technology (CIIT): CIIT uses for their initial data source all chemicals in commerce. For the purpose of setting priorities the chemicals are evaluated according to the following criteria: (1) commodity volume (high volume and several manufacturers), (2) pattern of distribution, (3) human exposure, (4) toxicological suspicion, (5) public interest, and (6) commercial significance (the benefits associated with the substance and the ease to which it could be replaced, i.e. cost).

One of the biases inherent in the CIIT list is that chemicals produced by only one manufacturer are eliminated from consideration. The other is that the benefit vs. risk of a

chemical is a value-judgement reflecting the mandate of the organization.

AD Pre-Chip Report; Chemicals evaluated by the Chemical Hazard Identification Branch came from a variety of sources. Examples of the sources include government research reports, structure activity analysis, chemical technology reviews, general literature scans and an original list of 15 chemicals designated by the Administrator. A document, describing this process is in draft in the Chemical Hazard Identification Branch. Chemicals being considered for Chip analysis are reviewed by the Chemical Hazard Information Branch. Professional judgement is used to decide which chemicals will go through the Chip evaluation.

# APPENDIX B

## ILLUSTRATIVE HISTOGRMS

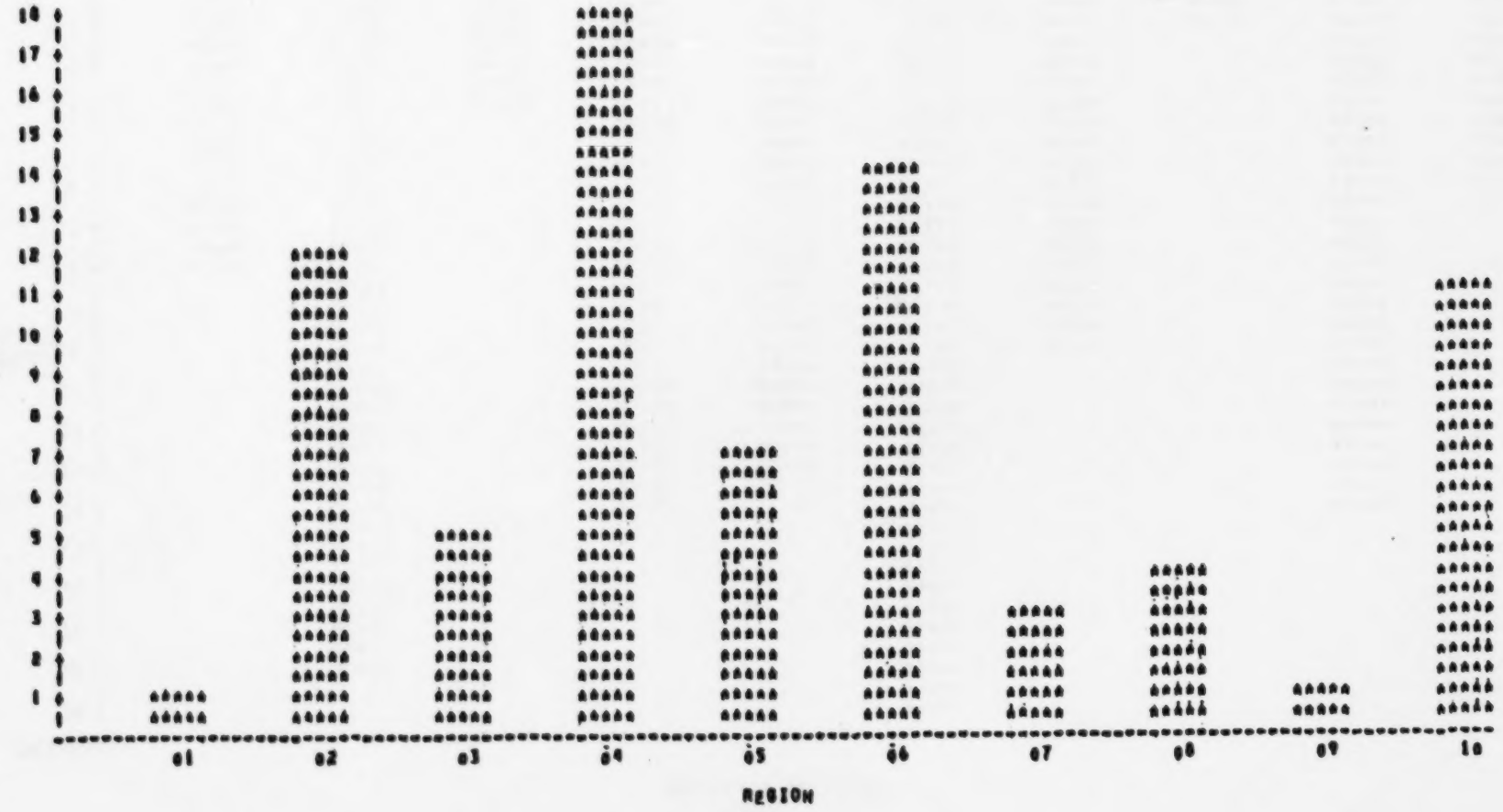
This section contains illustrative histograms of geographic and volume distributions for selected chemicals.

U. S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF PESTICIDES AND TOXIC SUBSTANCES
CHEMICAL INFORMATION DIVISION
CAS#=50000

Formaldehyde
FREQUENCY BAR CHART

11:46 MONDAY, FEBRUARY 4, 1980

Reproduced from best available copy.



U. S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF PESTICIDES AND TOXIC SUBSTANCES
CHEMICAL INFORMATION DIVISION
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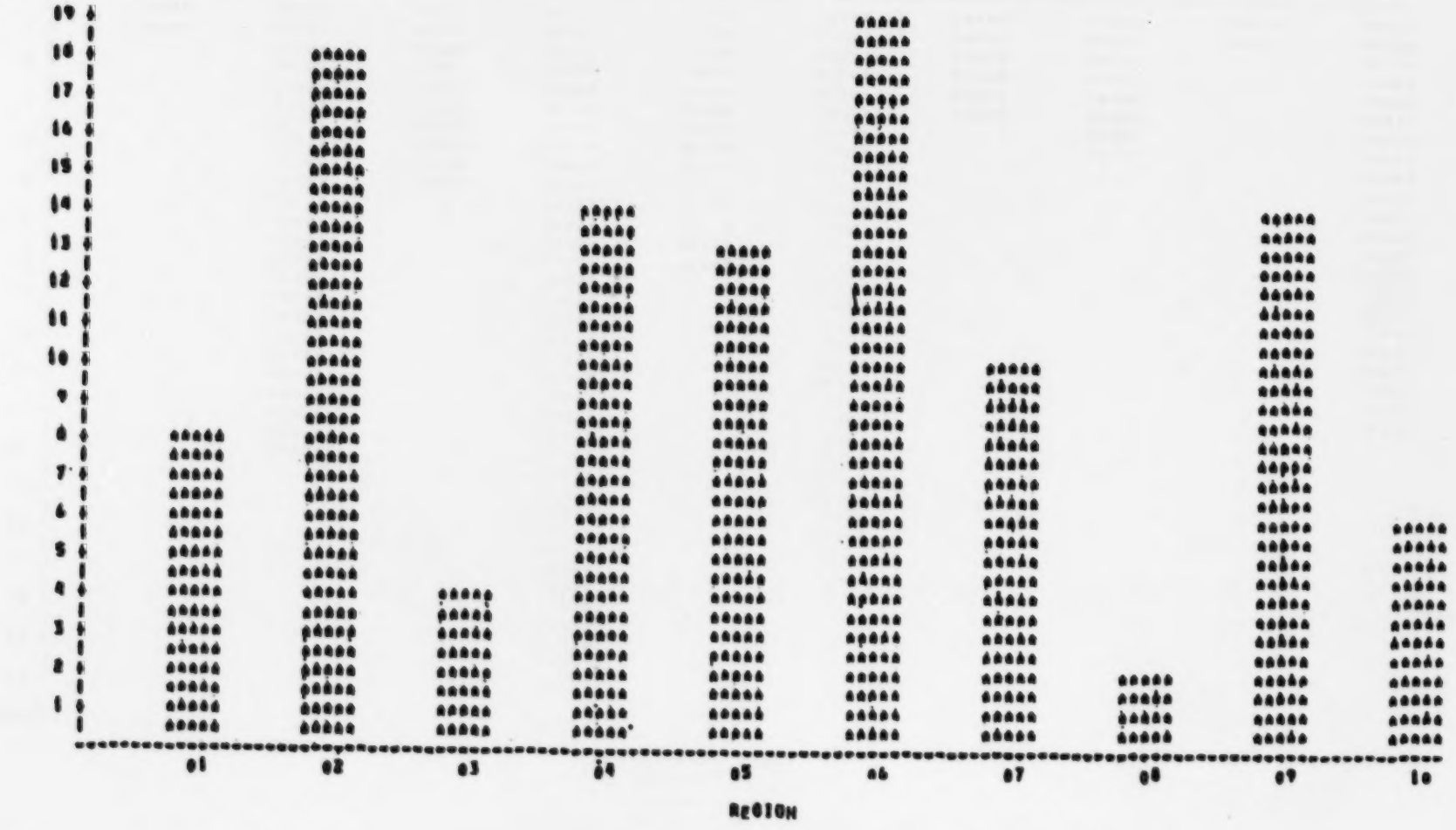
Urea

FREQUENCY BAR CHART



U. S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF PESTICIDES AND TOXIC SUBSTANCES
CHEMICAL INFORMATION DIVISION
CASNO=0000071432
Benzene
FREQUENCY BAR CHART

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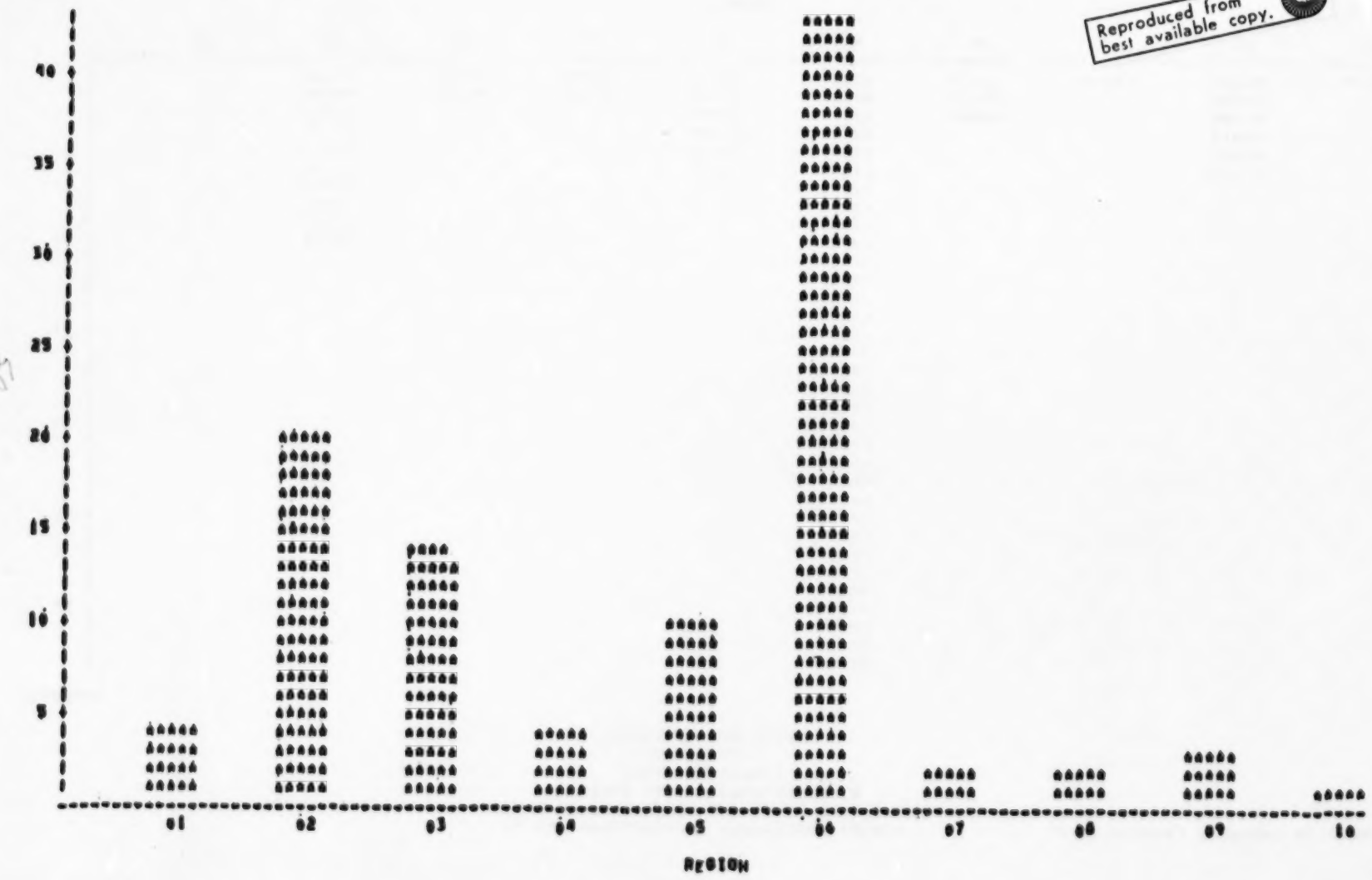
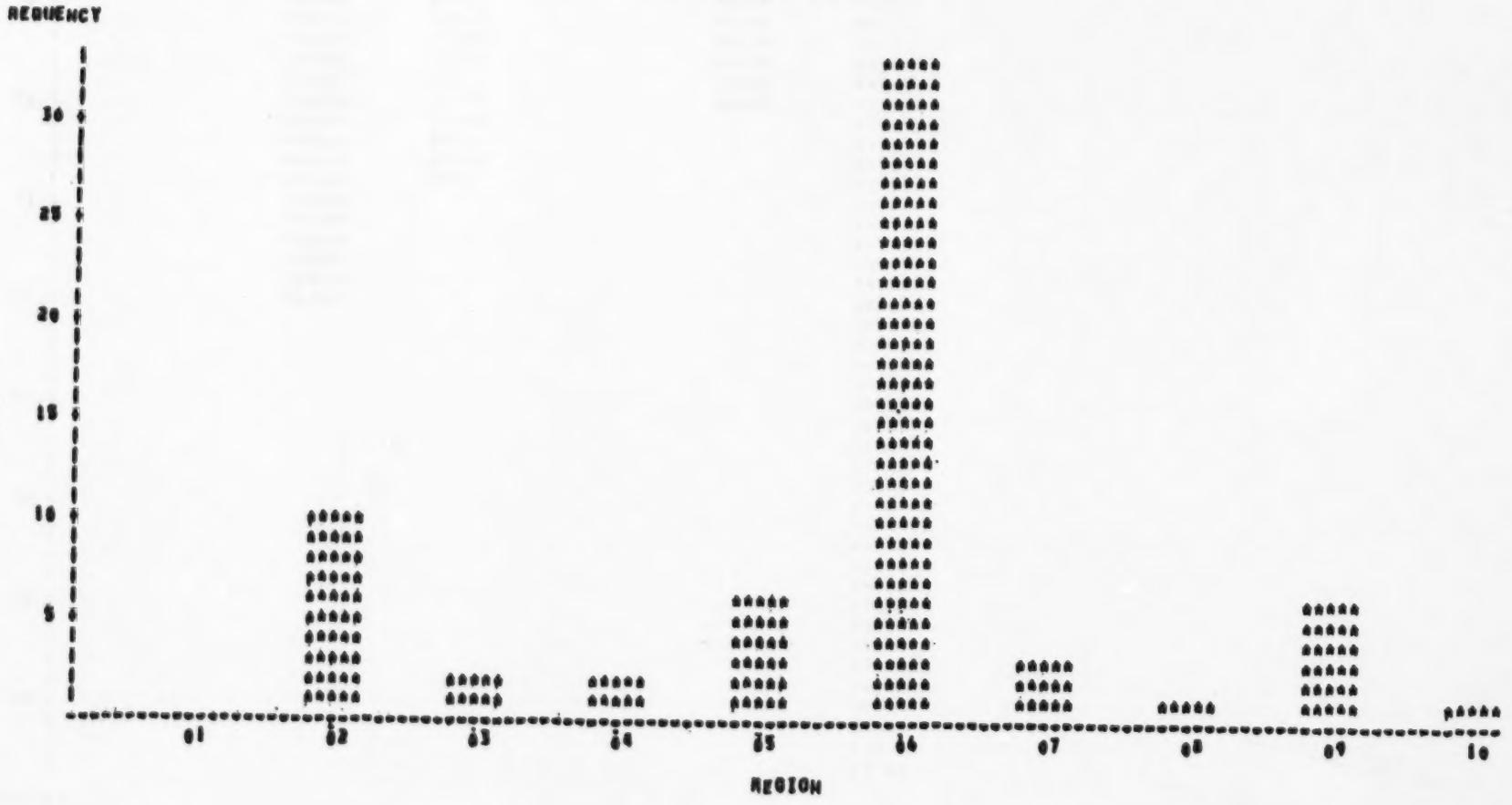


U. S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF PESTICIDES AND TOXIC SUBSTANCES
CHEMICAL INFORMATION DIVISION
CASNO=000074851

11:46 MONDAY, FEBRUARY 4, 1980 19

Ethylene
FREQUENCY BAR CHART



U. S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF PESTICIDES AND TOXIC SUBSTANCES
CHEMICAL INFORMATION DIVISION

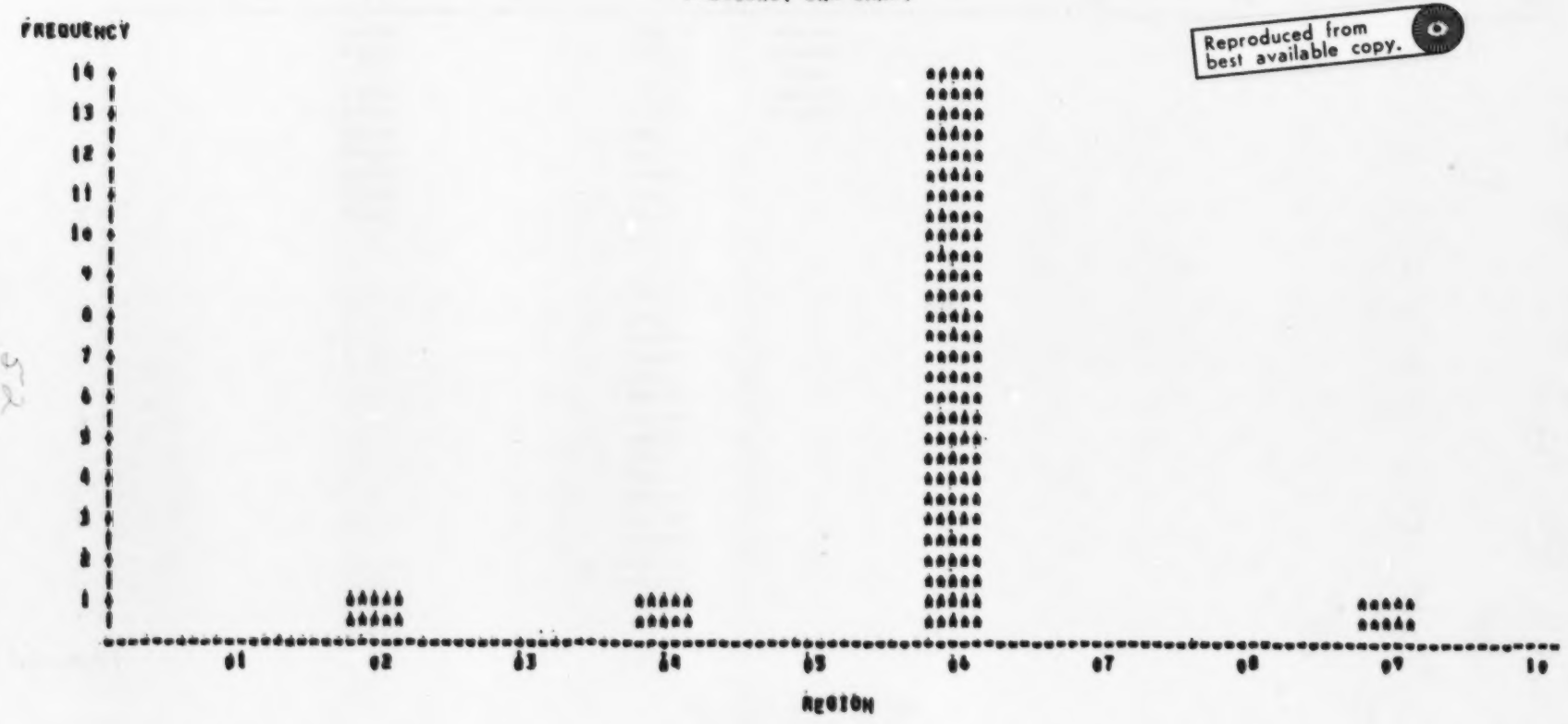
11:48 MONDAY, FEBRUARY 4, 1980 11

CASNO=000075014

Vinyl Chloride

FREQUENCY BAR CHART

Reproduced from best available copy.



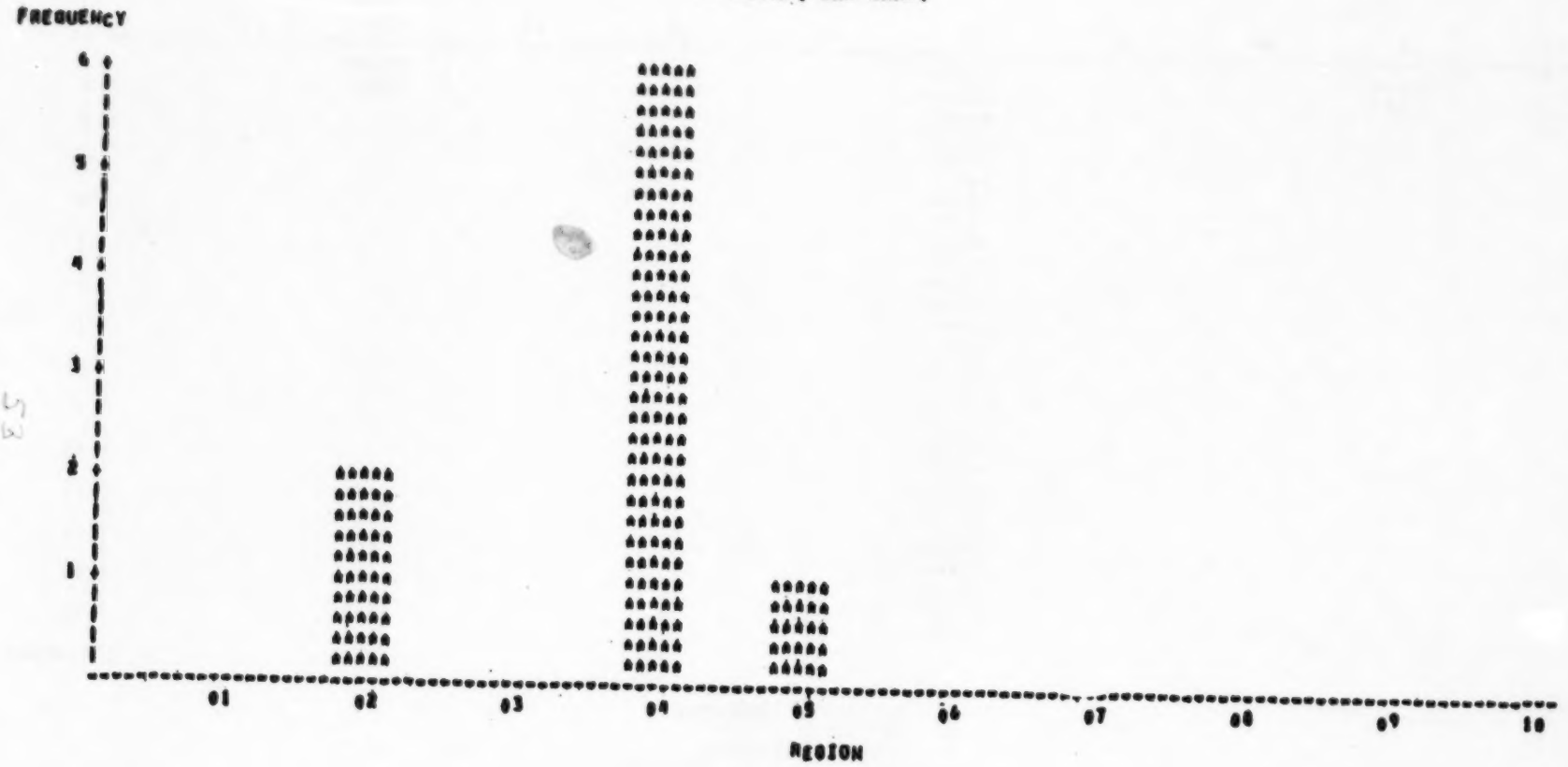
U. S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF PESTICIDES AND TOXIC SUBSTANCES
CHEMICAL INFORMATION DIVISION

11:48 MONDAY, FEBRUARY 4, 1980 15

CARNO=000100218

· Teraphthalic Acid

FREQUENCY BAR CHART



OFFICE OF PESTICIDES AND TOXIC SUBSTANCES
CHEMICAL INFORMATION DIVISION
CASNO=000050000
Formaldehyde
FREQUENCY BAR CHART

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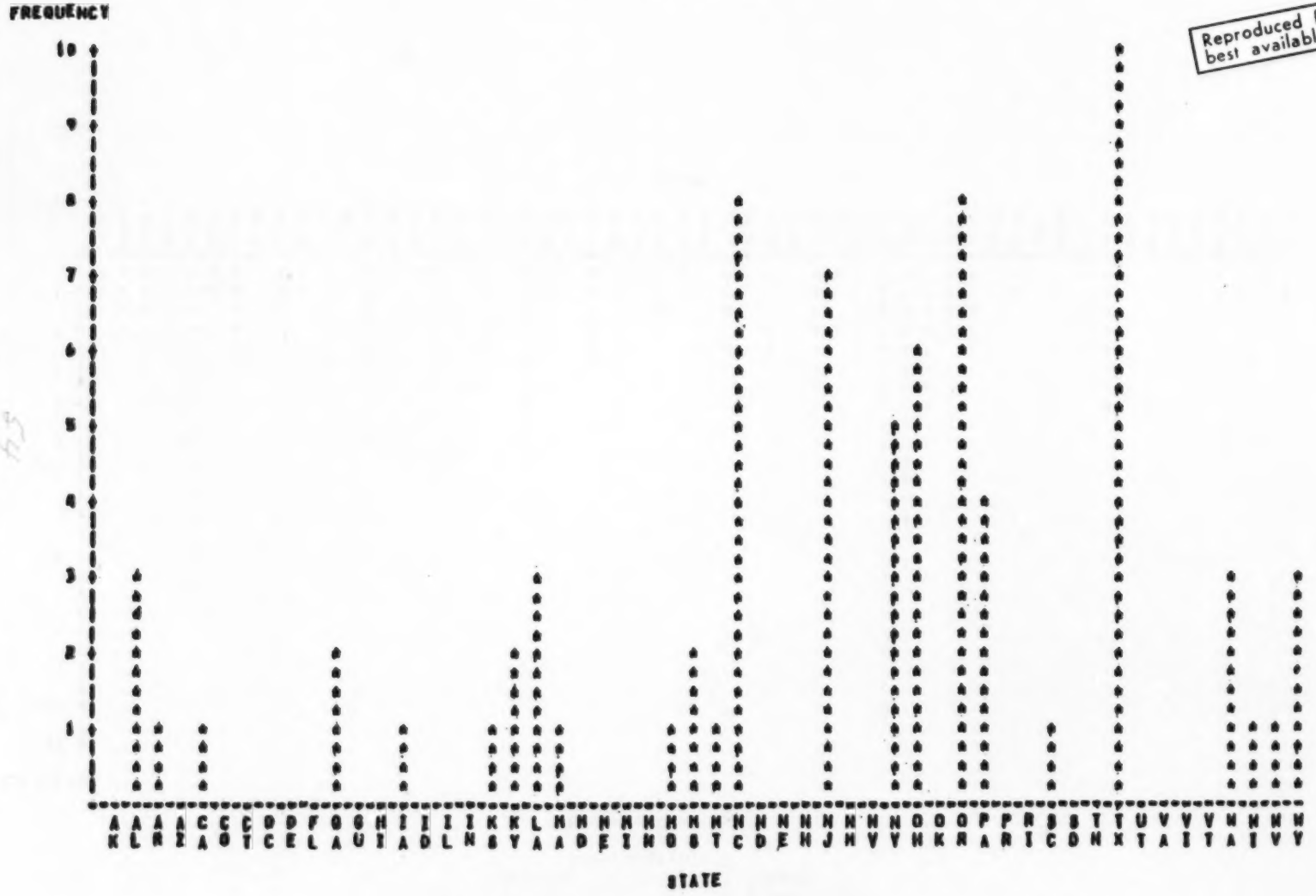
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6
5
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3
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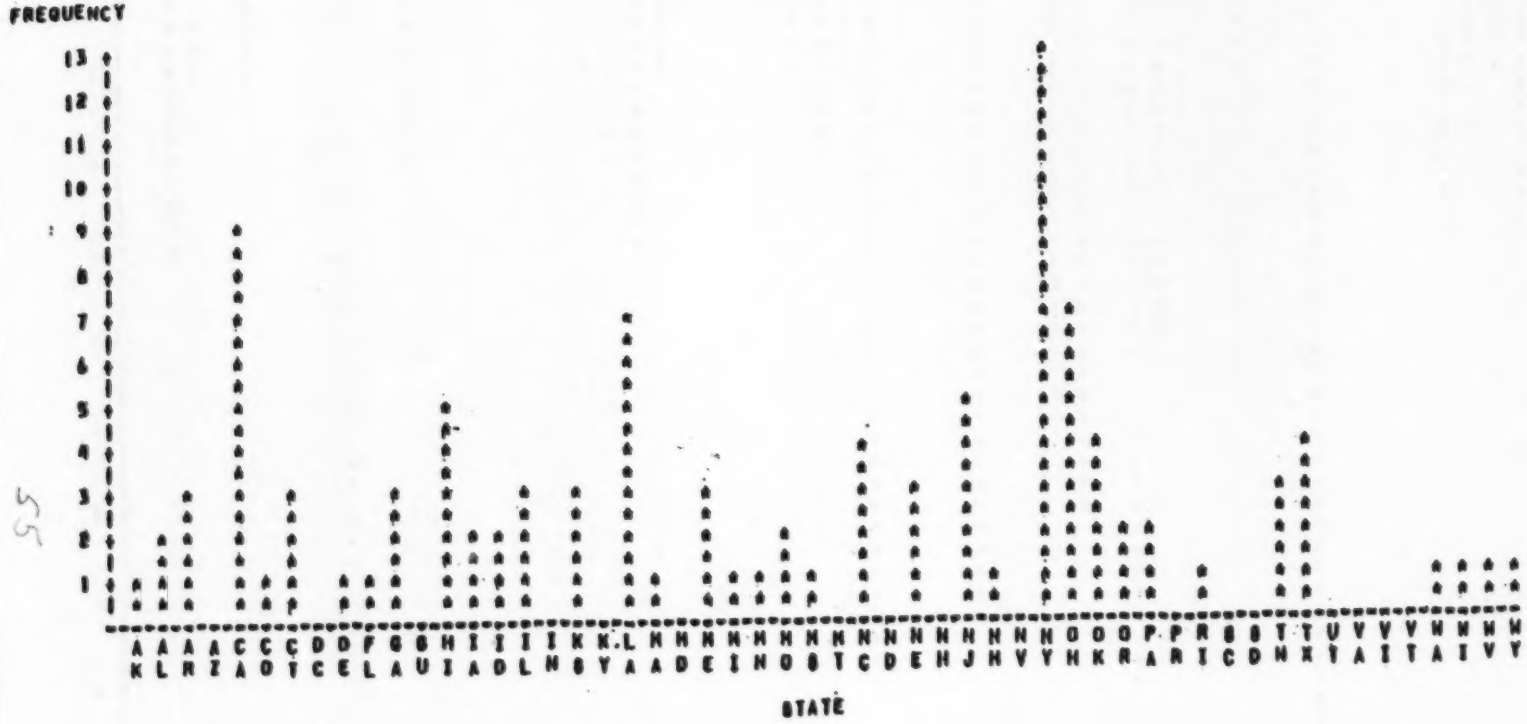
AK AL AR AZ CA CO CT DC DE FL GA GU HI ID IL IN KS KY LA MD ME MI MN MO MS MT NC ND NE NH NJ NM NV NY OH OK OR PA PR RI SC SD TN TX UT VA VI VT WA WI WV WY
STATE

U. S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF PESTICIDES AND TOXIC SUBSTANCES
CHEMICAL INFORMATION DIVISION
CASNO=000057134
Urea
FREQUENCY BAR CHART




55

OFFICE OF PESTICIDES AND TOXIC SUBSTANCES
CHEMICAL INFORMATION DIVISION
CASNO=0000071432
Benzene
FREQUENCY BAR CHART

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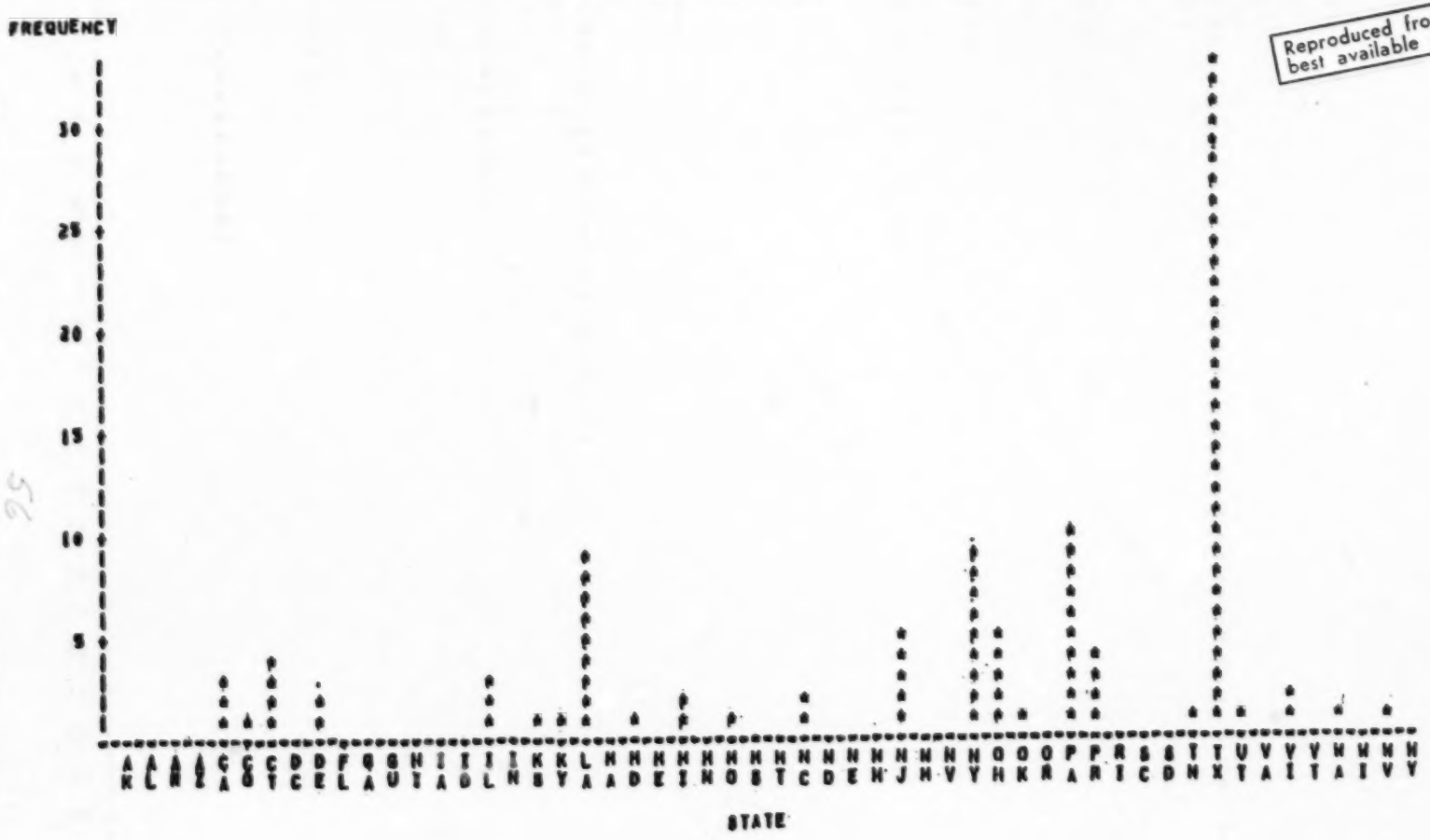
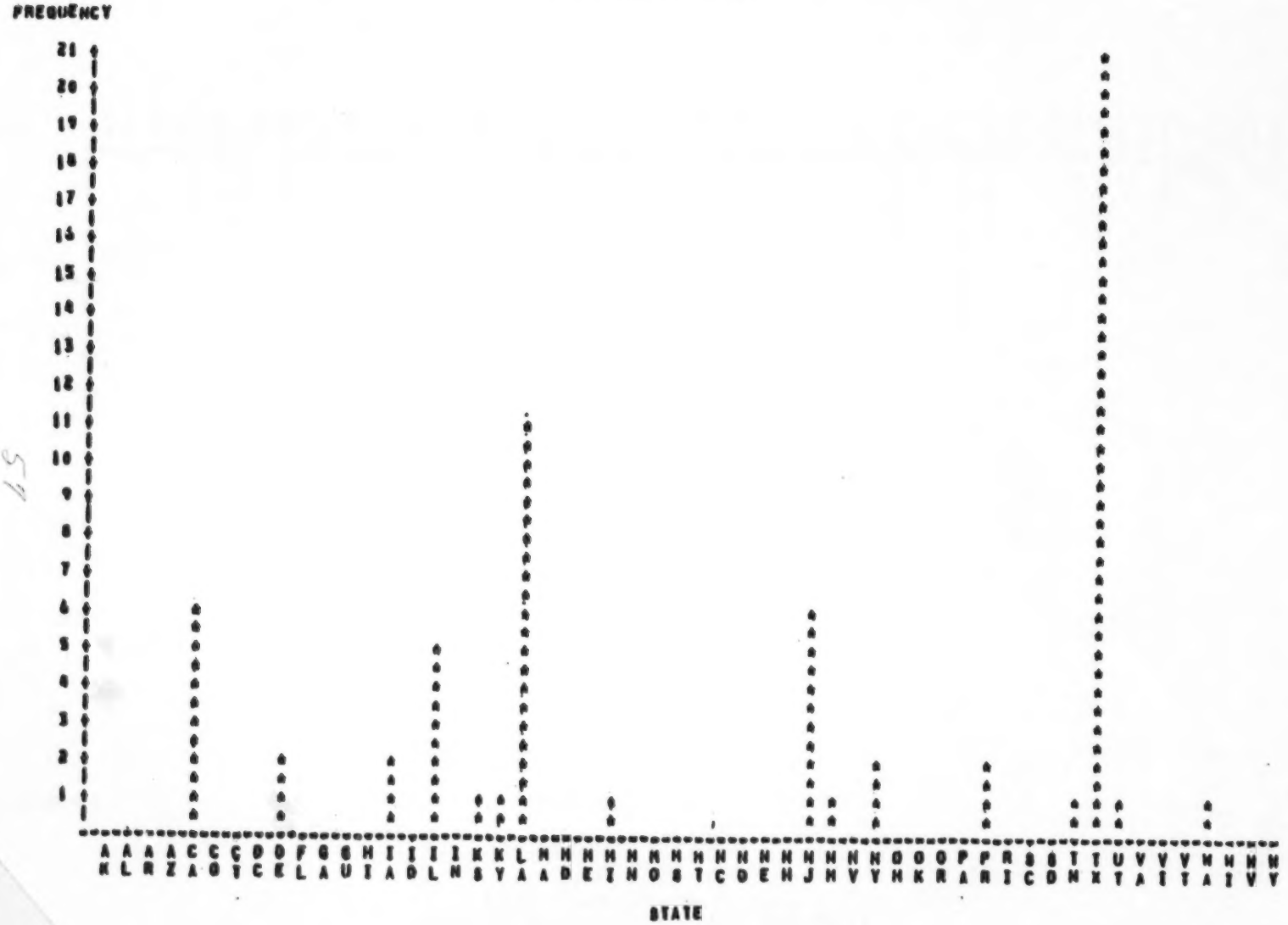


US ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF PESTICIDES AND TOXIC SUBSTANCES
CHEMICAL INFORMATION DIVISION
CASNO=000074851
Ethylene
FREQUENCY BAR CHART

11:56 MONDAY, FEBRUARY 4, 1980



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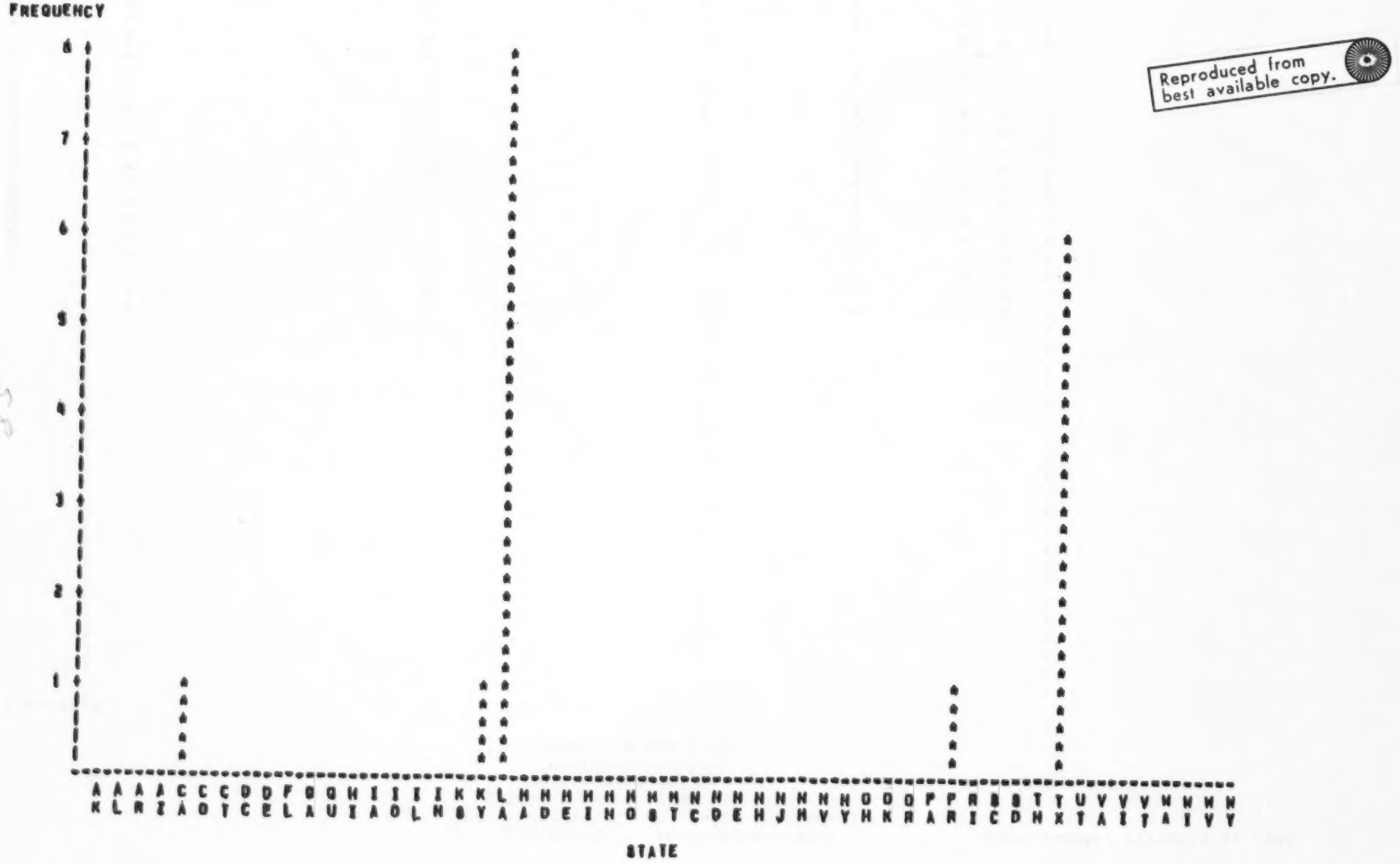
11156 MONDAY, FEBRUARY 4, 1980 11

CASNO=000075014
Vinyl Chloride
FREQUENCY BAR CHART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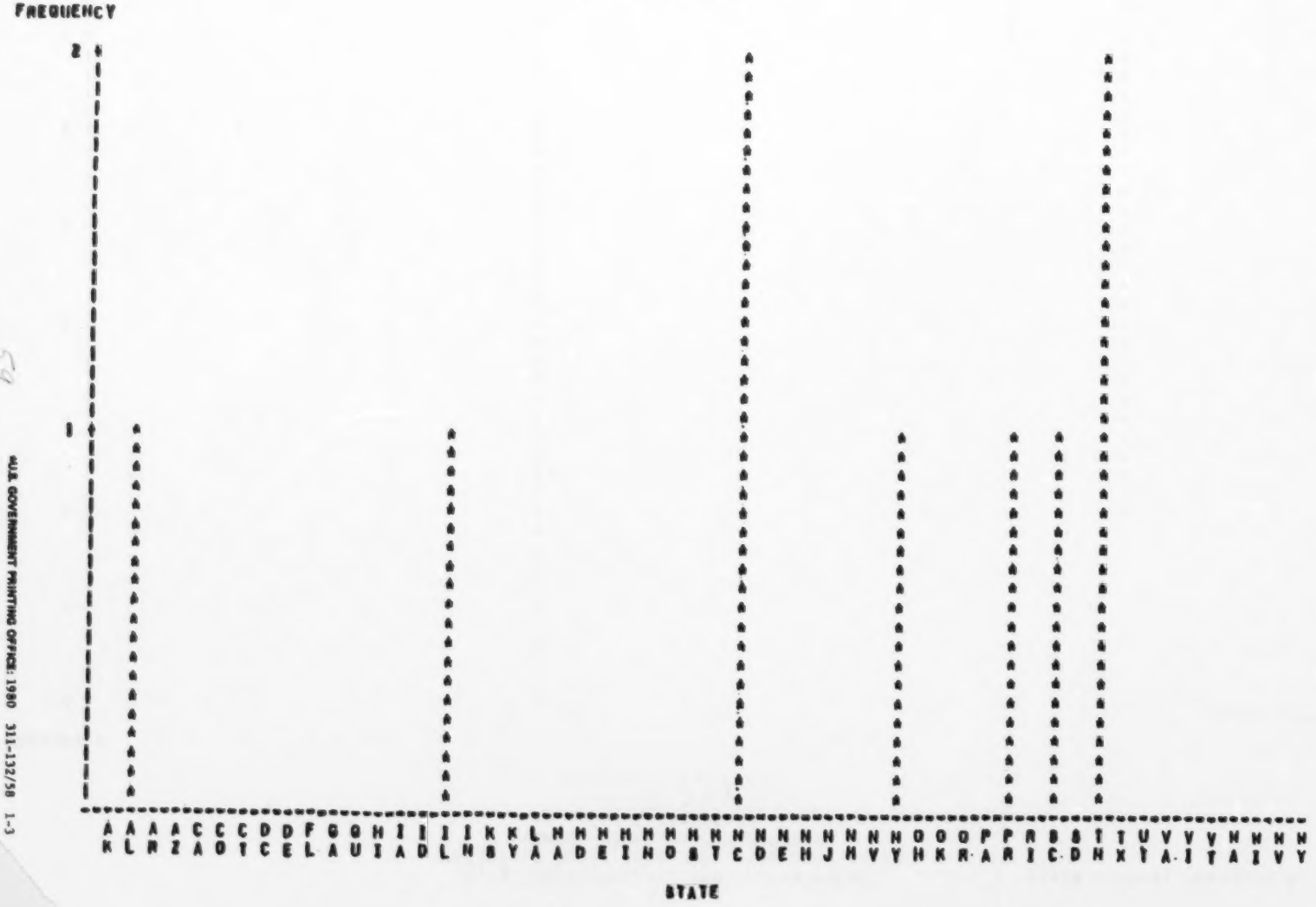
CHEMICAL INFORMATION DIVISION

11:56 MONDAY, FEBRUARY 4, 1980 15

CASNO=000100210

Teraphthalic Acid

FREQUENCY BAR CHART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AK AL AR AZ CA CO CT DC DE FL GA HI ID IL IN IA KS KY LA MD MA MI MN MS MO MT NE NV NH NJ NM NY NC ND OH OK OR PA RI SC SD TN TX UT VT VA WA WV WI WY
STATE

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